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EDLC CHARACTERISTICS OF CARBON MATERIALS DERIVED FROM COAL EXTRACT (HPC)

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Introduction

Hyper coal (HPC) is the thermally extracted ash-free component of coal, which dissolves in pyridine to yield a highly conductive viscous solution. This solution prepares carbon fiber precursors via an electrospinning equipment; subsequently, these precursors are heat treated. Carbon fibers obtained are dominated by micropores containing an approximately specific surface area of 1000 m^2 g^{-1}. Moreover, because the carbon fibers are obtained in the form of a nonwoven fabric, they are directly available as electrodes without a binder. A previous study reports that the specific capacitance of the electric double layer capacitor (EDLC) is 300 F g^{-1} at a current density of 50 mA g^{-1} [1]. When water is used for HPC as poor solvent, the HPC is precipitated from the solution, resulting in a powdered carbon precursor that is converted into a powdered carbon material through heat treatment. This study examines the EDLC characteristics of the microporous carbon powder using HPC as the raw material. Results indicate that the EDLC of the powdered carbon material without activation exceeded 50 mF cm^{-2} in aqueous sulfuric acid (H_2SO_4).

Materials and Methods

HPC was derived from bituminous coal and its powder was prepared via the poor-solvent method, in which it was dissolved in pyridine and subsequently precipitated by pouring the prepared HPC solution in water. The precipitated HPC powder was infusibilized by heating it at 300°C for 1 h in atmosphere and carbonized by heating it at 900°C for 30 min under N_2 atmosphere. The surface characteristics of the prepared carbon powder were evaluated through N_2 adsorption–desorption measurement, and its specific surface area was calculated through the a_S analysis of the adsorption isotherm. The EDLC electrode was prepared by mixing the carbon material, acetylene black, and polytetrafluoroethylene in the molar-weight ratio of 8:1:1. The EDLC characteristics were evaluated on a tripolar-type cell comprising a 40% H_2SO_4 electrolyte and an Ag/AgCl reference electrode. Galvanostatic constant-current charge–discharge measurements were taken within 50–5000 mA g^{-1}, whereas the electrostatic capacitance was calculated in the range of 0.2–0.8 V of the discharge curves. Fiber morphologies of the carbon materials pre- and post-heat treatment were observed on different spatial scales using an optical microscope and scanning electron microscope (SEM).

Results and Discussion

For the N_2 adsorption–desorption isotherms of the powdered carbon material obtained through the poor-solvent method, the adsorbed amount of the powdered carbon material increased sharply to 100 cc g^{-1} under zero relative pressure, indicating the formation of micropores. The specific surface area was around 400 m^2 g^{-1}. The EDLC characteristics were evaluated using the charge–discharge measurement (in the range of 0–1 V) of an electrode prepared using the powdered carbon material. Fig. 1 illustrates the charge–discharge curve at 50 μA g^{-1}. The electrostatic capacitance calculated within 0.2–0.8 V of the discharge curve was approximately 220 F g^{-1} (capacitance per unit area = 255 μF cm^{-2}), which is far higher than that of activated carbon (22 μF cm^{-2}). Fig. 2 describes the current-density dependence of the electrostatic capacitance. Apparently, the capacitance slightly decreased with an increase in current density; at the highest current density (5000 mA g^{-1}), the capacitance per unit area of the powdered carbon material prepared using the poor-solvent method was 46 μF cm^{-2}, confirming that 90% of capacitance at 50 mA g^{-1} was retained at 5000 mA g^{-1}. In summary, the capacitance of the powered-carbon-material electrode prepared using HPC as raw material was 50 μF cm^{-2}, sufficiently robust to an increase in current density.

Conclusions

This study evaluated the EDLC characteristics of the carbon material prepared using HPC derived from the thermal extraction of coal. The electrostatic capacitance per unit area was more than 50 μF cm^{-2}, indicating that the carbon material obtained from HPC solution is a promising electrode material with high capacitance.

Figure

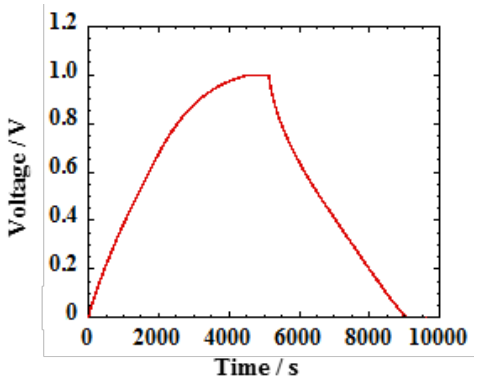

Fig. 1 Charge-discharge curve at 50 μA g^{-1}

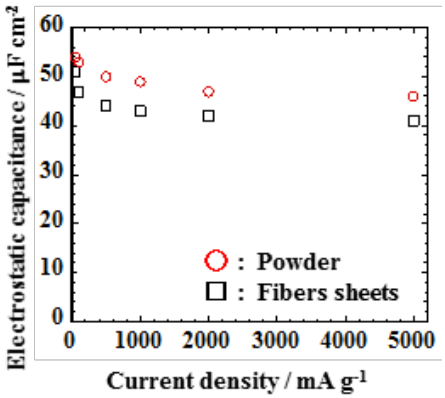

Fig. 2 Current density dependence of electrostatic capacitance

References

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